of gas produced, 61·50 cubic metres of illuminating gas, and 38·50 cubic metres of heating and motive-power gas.

This result would be obtained by receiving into separate reservoirs the gas produced during the first fifteen minutes, and during the last 1h. 45m. of the distillation, and in reserving for illuminating purposes the gas made in the interval of 0h. 15m. to 2h. 15m. of the charge from the commencement of the distillation.

STORAGE OF ELECTRIC ENERGY

THE following correspondence on this subject has appeared in the *Times*. By help of this and the communication in our issue of to-day from Sir W. Thomson, the reader will be able to understand the present position of this important question.

THE marvellous "box of electricity" described in a letter to you, which was published in the *Times* of May 16, has been subjected to a variety of trials and measurements in my laboratory for now three weeks, and I think it may interest your readers to learn that the results show your correspondent to have been by no means too enthusiastic as to its great practical value. I am continuing my experiments to learn the behaviour of the Faure battery in varied circumstances, and to do what I can towards finding the best way of arranging it for the different kinds of service to which it is to be applied. At the request of the Conseil d'Administration of the Société de la Force et la Lumière, I have gladly undertaken this work, because the subject is one in which I feel intensely interested, seeing in it a realisation of the most ardently and unceasingly felt scientific aspiration of my life—an aspiration which I scarcely dared to expect or to hope to live to see realised.

The problem of converting energy into a preservable and storable form, and of laying it up in store conveniently for allowing it to be used at any time when wanted, is one of the most interesting and important in the whole range of science. It is solved on a small scale in winding up a watch, in drawing a bow, in compressing air into the receiver of an air-gun or of a Whitehead torpedo, in winding up the weights of a clock or other machine driven by weights, and in pumping up water to a height by a windmill (or otherwise, as in Sir William Armstrong's hydraulic accumulator) for the purpose of using it afterwards to do work by a waterwheel or water pressure on a piston. It is solved on a large scale by the application of burning fuel to smelt zinc, to be afterwards used to give electric light or to drive an electro-magnetic engine by becoming, as it were unsmelted in a voltaic battery. Ever since Joule, forty years ago, founded the thermodynamic theory of the voltaic battery and the electro-magnetic engine, the idea of applying the engine to work the battery backwards and thus restore the chemical energy to the materials so that they may again act voltaically, and again and again, has been familiar in science. But with all ordinary forms of voltaic battery the realisation of the idea to any purpose seemed hopelessly distant. By Planté's admirable discovery of the lead and peroxide of lead voltaic battery, alluded to by your correspondent, an important advance towards the desired object was made twenty years ago; and now by M. Faure's improvement practical fruition is attained.

The "million of foot pounds" kept in the box during its seventy-two hours' journey from Paris to Glasgow was no exaggeration. One of the four cells, after being discharged, was recharged again by my own laboratory battery, and then left to itself absolutely undisturbed for ten days. After that it yielded to me 260,000 foot pounds (or a little more than a quarter of a million). This not only confirms M. Reynier's measurements, on the faith of which your correspondent's statement was made; it seems further to show that the waste of the stored energy by time is not great, and that for days or weeks, at all events, it may not be of practical moment. This, however, is a question which can only be answered by careful observations and measurements carried on for a much longer time than I have hitherto had for investigating the Faure battery. I have already ascertained enough regarding its qualities to make it quite certain that it solves the problem of storing electric energy in a manner and on a scale useful for many important practical applications. It has already had in this country one interesting application, of the smallest in respect to dynamical energy used, but not of the smallest in respect to beneficence, of all that may be expected of it. A few days ago my colleague, Prof. George Buchanan, carried away from my laboratory one of the lead cells (weighing about 18 lbs.) in his carriage, and by it ignited the thick platinum wire of a galvanic *écraseur* and bloodlessly removed a nævoid tumour from the tongue of a young boy in about a minute of time. The operation would have occupied over ten minutes if performed by the ordinary chain *écraseur*, as it must have been had the Faure cell not been available, because in the circumstances the surgical electrician, with his pharaphernalia of voltaic battery to be set up beforehand, would not have been practically admissible.

The largest useful application waiting just now for the Faure battery—and it is to be hoped that the very *minimum* of time will be allowed to pass till the battery is supplied for this application—is to do for the electric light what a water cistern in a house does for an inconstant water supply. A little battery of seven of the boxes described by your correspondent suffices to give the incandescence in Swan or Edison lights to the extent of 100 candles for six hours, without any perceptible diminution of brilliancy. Thus, instead of needing a gas engine or steam engine to be kept at work as long as the light is wanted, with the liability of the light failing at any moment through the slipping of a belt—an accident of too frequent occurrence—or any other breakdown or stoppage of the machinery, and instead of the wasteful inactivity during the hours of day or night when the light is not required, the engine may be kept going all day and stopped at night, or it may be kept going day and night, which will undoubtedly be the most economical plan when the electric light comes into general enough use. The Faure accumulator, always kept charged from the engine by the house supply wire, with a proper automatic stop to check the supply when the accumulator is full, will be always ready at any hour of the day or night to give whatever light is required. Precisely the same advantages in respect of force will be gained by the accumulator when the electric town supply is, as it surely will be before many years pass, regularly used for turning lathes and other machinery in workshops and sewing-machines in private houses.

Another very important application of the accumulator is for the electric lighting of steam-ships. A dynamo-electric machine of very moderate magnitude and expense, driven by a belt from a drum on the main shaft, working through the twenty-four hours, will keep a Faure accumulator full, and thus, notwithstanding irregularities of the speed of the engine at sea or occasional stoppages, the supply of electricity will always be ready to feed Swan or Edison lamps in the engine-room and cabins, or arc lights for mast-head and red and green side lamps, with more certainty and regularity than have yet been achieved in the gas supply for any house on *terra firma*.

I must apologise for trespassing so largely on your space. My apology is that the subject is exciting great interest among the public, and that even so slight an instalment of information and suggestions as I venture to offer in this letter may be acceptable to some of your readers. WILLIAM THOMSON.

The University, Glasgow, June 6.

ALTHOUGH agreeing with every word of Sir William Thomson's letter in the *Times* of to-day, and entirely sympathising with his enthusiasm as regards the marvellous box of electricity, still I feel that it would have been desirable if in pointing out the importance of this new discovery Sir William Thomson had guarded against a very probable misconstruction of the purport of his letter.

The means of storing and re-storing mechanical energy form the aspiration not only of Sir William, but of every educated mechanic. It is, however, a question of degree—of the amount of energy stored as compared with the weight of the reservoir, the standard of comparison being coal and corn. Looked at in this way one cannot but ask whether, if this form of storage is to be the realisation of our aspirations, it is not completely disappointing. Large numbers are apt to create a wrong impression until we inquire what is the unit. Eleven million foot pounds of energy is what is stored in 1 lb. of ordinary coal. So that in this box, weighing 75 lb., there was just as much energy as in 1¼ oz. of coal, which might have been brought from Paris or anywhere else in a waistcoat pocket, or have been sent by letter.

When we come to the question of the actual conveyance of energy for mechanical purposes, this view is of fundamental importance. The weight of the same amount of energy in the new form is 800 times greater than the equivalent amount of coal; and as a matter of economy, supposing that energy in this

form might be had at a certain spot and no capital were required for its conversion or storage, and that the energy were directly applicable it could not be carried ten miles—that is to say, such energy cannot be economically useful ten miles from its source, although coal had to be carried 100 miles to the spot. This limit, in truth, falls far short of what has been already attained by other means. By wire ropes and by compressed air or steam energy may be economically transmitted from ten to twenty miles. So that if this is the utmost of what is to be done by means of the storage of electricity this discovery adds another door to those which are hopelessly closed against the possibility of finding in Niagara or other water power a substitute for our coal, even when the object is motive power, and much more for that purpose for which five-sixths of our coal is used—the production of heat.

It is very important that the people of this country should not shut their eyes to the fact that, so far from there being a greater prospect of the solution of the problem than when, about twenty years ago, Prof. Jevons raised the alarm, the prospect is now much smaller. In the meantime the capabilities of steel ropes, fluids in pipes, and electricity along conductors have been not only investigated, but practically tested, and found altogether wanting. And now it would seem that the storage of electricity must be added to the list. OSBORNE REYNOLDS

Owens College, June 9

YOUR leading article in the *Times* of yesterday, on the storage of electricity, alludes to my having spoken of Niagara as the natural and proper chief motor for the whole of the North American Continent. I value the allusion too much to let it pass without pointing out that the credit of originating the idea and teaching how it is to be practically realised by the electric transmission of energy is due to Mr. C. W. Siemens, who spoke first, I believe, on the subject in his presidential address to the Iron and Steel Institute in March, 1877. I myself spoke on the subject in support of Mr. Siemens's views at the Institution of Civil Engineers a year later. In May, 1879, in answer to questions put to me by the Select Committee of the House of Commons on Electric Lighting, I gave an estimate of the quantity of copper conductor that would be suitable for the economical transmission of power by electricity to any stated distance; and, taking Niagara as example, I pointed out that, under practically realisable conditions of intensity, a copper wire of half an inch diameter would suffice to take 26,250 horse-power from water-wheels driven by the Fall, and (losing only 20 per cent. on the way) to yield 21,000 horse-power at a distance of 300 British statute miles; the prime cost of the copper amounting to 60,000*l.*, or less than 3*l.* per horse-power actually yielded at the distant station. WILLIAM THOMSON

The University, Glasgow, June 9

IF you do me the honour to publish a letter which I wrote to you yesterday regarding the electric transmission of energy it will be seen that I thoroughly sympathise with Prof. Osborne Reynolds in his aspirations for the utilisation of Niagara as a motor, but that neither Mr. Siemens nor I agree with him in the conclusion which he asserts in his letter to you, published in the *Times* of to-day, that electricity has been tried and found wanting as a means for attaining such objects. The *transmission* of power was not the subject of my letter to you published in the *Times* of the 9th inst., and Prof. Reynolds' disappointment with M. Faure's practical realisation of electric *storage*, because it does not provide a method of *porterage* superior to conduction through a wire, is like being disappointed with an invention of improvements in water cans and water reservoirs because the best that can be done in the way of movable water cans and fixed water reservoirs will never let the water-carrier supersede water-pipes wherever water-pipes can be laid.

The $1\frac{1}{2}$ oz. of coal cited by Prof. Osborne Reynolds as containing a million of foot-pounds stored in it is no analogy to the Faure accumulator containing the same amount of energy. The accumulator can be re-charged with energy when it is exhausted, and the fresh store drawn upon when needed, without losing more than 10 or 15 per cent. with arrangements suited for practical purposes. If coal could be unburned—that is to say, if carbon could be extracted from carbonic acid by any economic process of chemical or electric action, as it is in nature by the growth of plants drawing on sunlight for the requisite energy—the result would be analogous to what is done in Faure's accumulator. WILLIAM THOMSON

The University, Glasgow, June 11

DR. MIKLUCHO MACLAY'S ANTHROPOLOGICAL AND ANATOMICAL RESEARCHES IN MELANESIA AND AUSTRALIA[1]

AFTER I had left Sydney in March, 1879, I visited the following islands: New Caledonia, Lifu; of the New Hebrides: Tana, Vate, Tongoa, Mai, Epi, Ambrim, Malo, Vanua Lava; the Admiralty Islands; the groups—Lub (or Hermit), Ninigo (Echiquier), Trobriant, the Solomon Islands, the islands at the south-east end of New Guinea, and the islands of Torres Straits.[2]

Only a very few of the results of the journey can be comprehended in a short *résumé*, of these the first two of the following appear to me to be the most important:—1. Many islands of Melanesia[3] (especially some of the islands of the New Hebrides, of the Solomon Group, of the Louisiades, New Ireland, &c., &c.) possess a well-marked brachycephalic population (the breadth-index of many heads exceeds eighty, and sometimes even eighty-five), which circumstance is assuredly not ascribable to a mixture with another race, and proves that brachycephalism has a much wider range in Melanesia than has been hitherto supposed. This is a result of numerous careful measurements of heads and skulls[4] of the aboriginals of different islands of Melanesia. 2. Although in some villages of the southern coast of New Guinea there is noticeable a Polynesian admixture, yet this circumstance by no means permits of the aboriginals of the south-eastern peninsula (who are a branch of the Melanesian stock) being called a "yellow Malayan race," as has been frequently done of late years. 3. An acquaintance with the languages of the group Lub (or Hermit) and the dialects of the northern coast of the large island of the Admiralty Group, as well as the native traditions of the former, has shown that the population of the group Lub emigrated from the Admiralty Islands. Further acquaintance with the natives of Lub proved that there is among them a Polynesian admixture, which has resulted from the carrying off of the women of the group Ninigo, and from a frequent intercourse with the inhabitants (also a Melano-Polynesian race) of the smaller group Kaniet or Kanies (or Anchorites). My stay among the inhabitants of the Admiralty Islands has afforded me a glimpse of many interesting customs of the islands; but an account of these observations and researches cannot be condensed within the compass of a few sentences. To this series of results belong also the observations which I never neglected to make during the journey in Melanesia whenever the opportunity presented itself—especially observations on their customs, such as the deformation of the head, tattooing, perforation of the septum narium, alæ nasi, lobes and margins of the ears. I have also succeeded in making further observations, and obtaining more information, on the macrodontism in the Admiralty and Lub islands.

On my way back from the islands of Torres Straits I visited Brisbane, where I at first only intended to remain a few days. Here however a favourable opportunity presented itself of acquiring some interesting anatomical material for my anthropological researches, which circumstance induced me to prolong my stay for several months. I found, namely, that there was a possibility of continuing my researches on the comparative anatomy of the brain of the different varieties of the genus *homo*, which were commenced in 1873 in Batavia and resumed in Sydney in 1878. Although the material in question consisted only of three brains, yet I find that this new contribution to our knowledge of race-anatomy supports the view which I may briefly summarise as follows:—The investigation of the brains of representatives of different races of men shows that there occur peculiarities of by no means trifling import, which one cannot regard as individual variations. To this category belong differences in the development of the corpus callosum of the pons varolii, of the cerebellum; differences in the volume of the cranial nerves, and so forth; also the arrangement of the convolutions of the cerebrum is different, and I believe that in

[1] From a paper read before the Linnean Society of New South Wales February 23, 1881, by Dr. N. De Miklucho-Maclay. Revised and transmitted by the author.

[2] A more detailed account of the route, of the time spent at the different places, with sketch-maps of the routes and other details, will be found in my communication to the Imperial Russian Geographical Society, in the Jswestija of the Society.

[3] By the name "Melanesians" I designate exclusively the frizzly-haired inhabitants of the South Sea Islands.

[4] In order to eliminate any doubt as to the correctness of the cranial measurements on living individuals, I have not neglected to collect a considerable number of undoubtedly authentic skulls from New Caledonia, New Guinea, the Admiraltys, Ninigo, and Solomon Islands.